Thesis/
Reports
Gosz,
J. R.

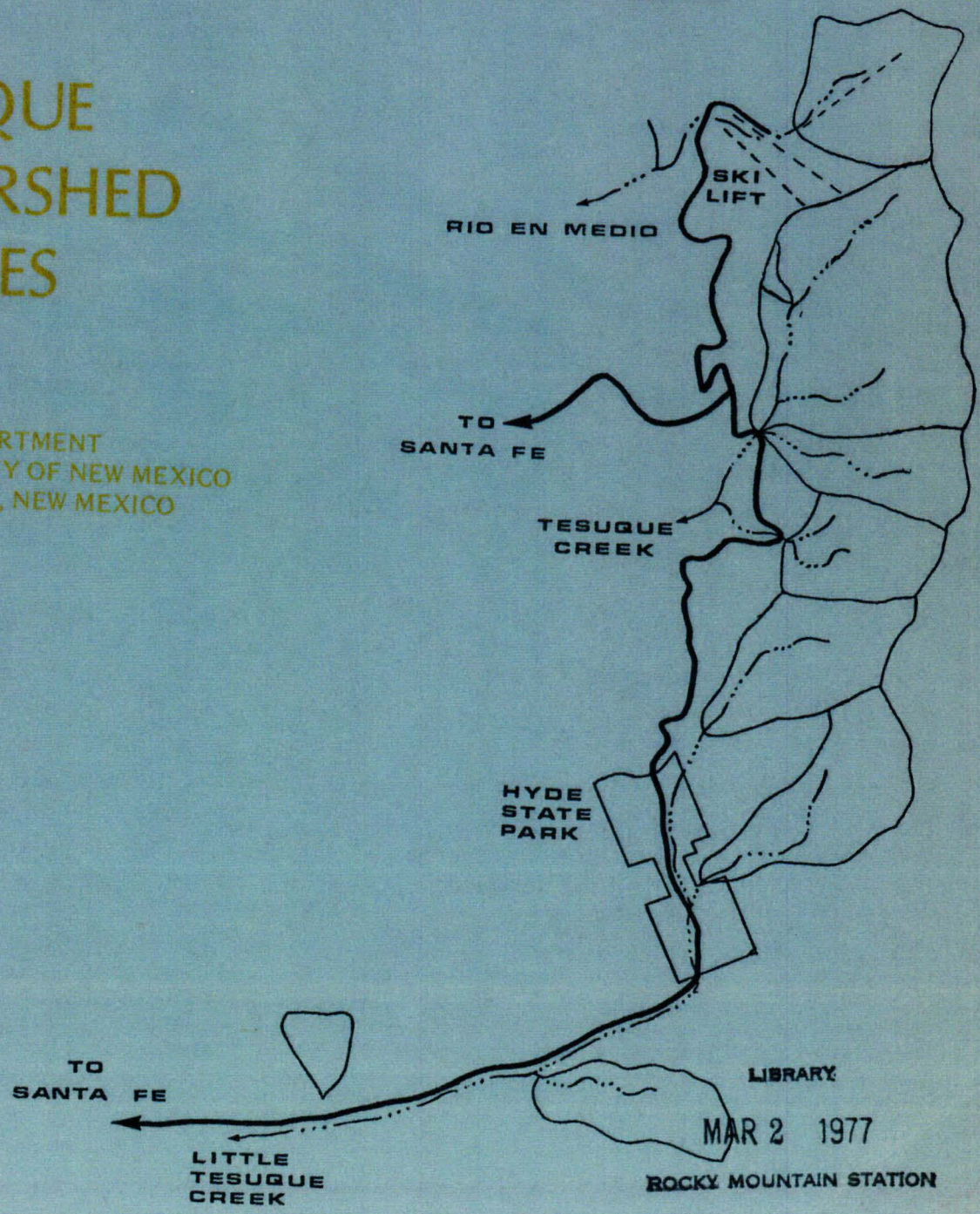
EFFECTS OF SOIL AMENDMENTS ON VEGETATION STRESSED BY ROAD SALT

James R. Gosz

EFFECTS OF SOIL AMENDMENTS ON VEGETATION STRESSED BY ROAD SALT

TESUQUE WATERSHED STUDIES

BIOLOGY DEPARTMENT
THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO



LIBRARY
MAR 2 1977
ROCKY MOUNTAIN STATION

EFFECTS OF SOIL AMENDMENTS ON VEGETATION STRESSED BY ROAD SALT

by

James R. Gosz
Associate Professor
Biology Department
The University of New Mexico

A Final Report
for
Agreement No. 16-524-CA
(Eisenhower Consortium #177)

February 1977

LIBRARY COPY
ROCKY MT. FOREST & RANGE
EXPERIMENT STATION

EFFECTS OF SOIL AMENDMENTS ON VEGETATION STRESSED BY ROAD SALT

INTRODUCTION

The increased use of forested areas for recreation and second homesites has resulted in road improvement activities and winter road salting. The use of road salt to maintain ice free roads has long been an accepted practice. Herrington (1967) lists five potential ski areas in New Mexico and sixteen in Colorado. It is anticipated that the roads built to service these facilities will be salted.

Road salting has been shown to lead to the development of stress symptoms in roadside vegetation in many portions of the United States and Canada (Button and Peaslee, 1967; Hall, Hofstra and Lumis, 1972; Menlove, 1973; Piatt and Krause, 1974; Shortle and Rich, 1970). The development of stress symptoms in aspen vegetation in New Mexico has been related to the accumulation of chloride in leaves as a result of road salting practices. Accumulation of damaging amounts of chloride occurs only in areas in which soil chloride concentrations are abnormally high--the result of a decrease in available soil water and increased soil chloride contents.

Our past and present studies of a road in the Sangre de Cristo Mountains of New Mexico which is subject to salting activities have identified many of the individual factors and the interactions which significantly contribute to the development and severity of vegetation

damage. The concentration of chloride within the soil is believed to be of prime concern in the development of stressful levels of chloride within the vegetation. As the concentration of soil chloride is dependent upon both the amount of chloride present and the water content of the soil, any treatment which increases the water holding capacity of the soil should reduce vegetation damage. The soils below the salted road are significantly drier than soils above the road. The lower water content in the below-road sites is a result of significantly larger proportions of sand (road salt is applied as a sand/salt mixture), and significantly lower amounts of organic matter and clay. This report deals with the results of two tests designed to control or reduce the undesirable effects of road salting; 1) the application of a straw mulch, and 2) the application of humate.

Springfield (1972) found that mulching with straw significantly increased water holding capacity. His results are of major importance for they were conducted in Santa Fe--approximately 13 km SW and 600 m lower in elevation than our study sites. It was expected that straw mulch applied in the amounts Springfield utilized under the mesic conditions of our study sites would result in a significant increase in available soil water.

Humate, which is a carbonaceous claystone or mudstone, has been shown to be relatively high in both organic matter and clay and its application to the disturbed sites should increase the water holding capacity of the soil. As humate deposits are abundant in the Southwest (being commonly associated with coal beds) the application of this

substance could be economically feasible for large scale applications to disturbed sites.

OBJECTIVES

The specific objectives of this study were to:

1) quantify the effectiveness of several soil amendments in reducing damage to roadside vegetation subject to road salting practices;

2) utilize the results of objective 1 to formulate practical procedures to minimize adverse effects of road salting practices.

METHODS

Soil treatments were applied to sites which were known to be affected by road salt and whose physiographic characteristics had been previously determined. The straw mulch additive was applied in both 1975 and 1976 at two levels; amounts equivalent to 1035 kg/ha and 1925 kg/ha. The straw was uniformly distributed throughout the sites. The humate additive was only applied during one year (1975) at levels equivalent to 455 kg/ha and 910 kg/ha. On one site in 1975 a combination of straw mulch at 1035 kg/ha and humate at 455 kg/ha was applied to determine the effectiveness of the two treatments in combination. In all humate treatments, the material was broadcast throughout the sites as this would be the only economically feasible method of application over large areas.

Table 1 lists the physiographic and road characteristics of the experimental sites as well as the treatment levels. Due to wide variation in these characteristics between sites, an area immediately adjacent to

each experimental site was utilized as a control for the treatment applied to that site.

Prior to the application of these treatments the following parameters were measured for each site; number and size of all aspen trees, overstory damage, understory cover, soil chloride concentration, soil moisture content, and soil organic matter content. Following the application of the various treatments the above parameters were measured on a weekly basis. Soil moisture content was measured both gravimetrically and with soil moisture blocks, chloride content by specific ion electrode and organic matter content by loss on ignition.

RESULTS

Tables 2, 3, and 4 show the effects of the treatments on soil characteristics. The values indicate increases (+) or decreases (-) of a characteristic in the treated site in relation to the adjacent control site.

Soil Moisture

The soil moisture percentage was affected in some way by all treatments. The application of straw mulch generally caused a significant increase in soil moisture during the latter portion of the growing season (table 2). This was no doubt a result of the heavy rains during those months compared with virtually no rain in June and the ability of the mulch to hold more moisture as well as prevent soil moisture loss by evaporation. The only discernable difference between the light and heavy application rates occurred during June of 1976. The heavy straw application

caused a significantly higher soil moisture content presumably by preventing the soil from drying out as rapidly following the snow melt period.

The humate application caused a different pattern; significantly higher soil moisture during the early summer months (table 2). The reason for this is thought to be an increased moisture holding capacity due to the clay and organic matter content of the humate. The heavier humate application rate generally caused greater soil moisture contents than the light application and significantly greater moisture (than the control) for more months. This data suggests that the humate additive can maintain higher soil moisture during dry periods (little rain) while the mulch is more effective during the rainy season. If this is correct, a combination of humate and straw mulch might maintain significantly higher soil moisture throughout the summer months. From the data on our combination treatment I am unable to verify that hypothesis (table 2). While values (during 1976) were relatively high the variability was large enough so that only two months showed significant ($P < .05$) increases. Also, the site selected for the combination treatment was the steepest of the five (38^{o}) which would reduce the effectiveness of any treatment applied to it. I would expect that the same combination on a less steep slope or a combination of greater application rates of straw and humate would have increased soil moisture levels to a greater degree.

Soil Cl^{-}

As with soil moisture, soil chloride levels were affected in some way by all treatments (table 3). The similarity of results, significant

decreases in late summer months under mulch and in early summer months under humate, suggest that the changes in soil moisture were largely responsible for the treatment effects. The combination of straw mulch and humate again did not cause effects predicted by the same treatments individually, presumably for the reasons discussed under soil moisture. The significant decreases in Cl^- on the site with the combination treatment during June and July, 1976 suggest that humate may have been the more important of the two treatments.

Organic Matter

The straw mulch (especially 1925 kg/ha) appeared to be the better of the two treatments for increasing the organic matter content of the soil. This is no doubt a result of the higher weight applied (1925 kg/ha applied during each of the two years) and the ease at which mulch is broken down relative to humate. The humate applied contained about 18% organic matter, thus, only 164 kg of organic matter was applied per ha under the heavy humate treatment. Another factor which must be considered is that sand was applied during the salting operation in the winter of 1975-76. About 800 kg of sand (less than ¼ in dia) was applied per km of road during each salting trip (Gosz 1975, 1977). This appeared to balance out the breakdown and incorporation into the soil of organic matter from the 1035 kg/ha straw application rate, causing an insignificant change.

It is interesting that the combination of light humate and straw mulch caused greater increases in organic matter content than those treatments applied individually. While this is consistent with an earlier stated hypothesis I cannot explain why it affected organic matter content and not soil moisture and Cl^- concentration.

Understory Cover and Tree Injury

The cover of understory species was affected by both straw mulch and humate application but only the heavy application rates caused statistically significant increases. As with the organic matter contents, the combination of light humate and straw produced more statistically significant increases than did the same treatments applied individually.

Damage to the overstory canopy (as measured by the % of trees showing stress symptoms) appeared to be the most sensitive indicator of the treatment effects. Even where variables such as soil moisture, Cl^- level, organic matter content did not change significantly, as under light straw application the first year, the stress systems of the canopy were much reduced (table 6). All treatments decreased stress symptoms by a minimum of 7% (12% control-5% light humate, 1976) by the end of the growing season as well as delaying the onset of such symptoms. The reason for this increased sensitivity seems to be due to the fact that soil moisture, Cl^-, organic matter measurements represent "pool or state" variables. They reflect the level of the "pool", of Cl^- for example, at a point in time but not the dynamics of the "pool." The vegetation is sensitive to both "pool" size and rate processes and may be able to demonstrate treatment differences when Cl^- levels ("pool" size) do not appear to change.

RECOMMENDATIONS

Road salting activities are slowly but surely degrading the vegetation along the road under study. This is a well recognized effect throughout the country (Roth and Wall 1976). The obvious best answer is to stop the salting procedure; however, this may not be possible in view of the bare

pavement policy demanded by the public. Assuming that salting activity will continue, there are a number of modifications that can be suggested to reduce the effects on roadside vegetation.

In many situations road salt is used very liberally according to the feeling "if one pound is good, two pounds are better." The amount and frequency of salt application should vary with the temperature, storm conditions, and volume of traffic. Moderation, compromise, and regulation appear to offer the best prospects (Roth and Wall 1976). The most common deicing agent in the Southwest is NaCl because of its abundance and low cost. Other salts are available (e.g. $CaCl_2$) which have different properties and may perform better or reduce damage more under certain conditions. Calcium chloride is more effective through a greater range of temperature than NaCl and tends to be used at temperatures below $-7^{o}C$. Sodium chloride generally is more effective above this temperature. Calcium chloride reacts faster, achieving results more quickly; but NaCl remains effective over longer periods of time. Since both contain Cl^-, which is thought to be the chief agent in plant damage, the use of one salt over another may not reduce plant damage unless the use of a particular salt results in a decrease in the total amount applied. Calcium chloride does have one important advantage over NaCl as a result of the breakdown of soil structure caused by Na^+. This breakdown in structure reduces the soil permeability and moisture levels which have the effect of increasing the concentration of Cl^- in the soil solution.

In our study area as in many others, salt is often applied with sand to increase traction. Our results demonstrate that the application of sand may be as important in vegetation damage as salt. The change in

soil texture and structure results in a more arid soil which enhances the effect of the salt. It would seem that a simple but effective procedure would be to add mineral matter that would compliment the soils of the area. In our study area, which has gravelly soils (granite parent material), supplements of finer textured material or material which would eventually break down into silts and clays would greatly reduce vegetation damage. Our favorable results on the effects of humate additions suggest that these carbonaceous claystones might be applied with salt to reduce damage. I feel this procedure should be tested.

Finally, our data shows that soil additives can reduce vegetation damage through the process of increasing moisture holding capacity. I suspect that the heaviest application rates reported on in this study represent the minimum amounts that can be expected to reduce damage. In addition, under the current salting practices, these amendments probably have to be added every year.

It seems clear that it will be very difficult and expensive to completely stop damage to the natural vegetation of these typically mesic sites. Management may be able to reduce the damage symptoms; however, the stress to these forest species caused by even modest salt levels will result in reduced productivity, reduced disease and insect resistance, and after a period of years, death. It would seem that a planting program using salt tolerant and cool tolerant species (e.g. many grasses) would have to be initiated to be assured of maintaining vegetation on these roadside sites. Our current research is evaluating the use of these grass species not only for their revegetation ability but also for their ability to reduce the degradation of stream water quality.

REFERENCES

Button, E. F. and D. E. Peaslee. 1967. The effects of road salt upon sugar maples in Connecticut. Highway Res. Record, 161:121-131.

Gosz, J. R. 1975. Stream chemistry as a tool in evaluating ski area development. pp. 183-194. In: Man, Leisure, and Wildlands: A complex interaction. Eisenhower Consortium Bulletin 1. 286 pp.

Gosz, J. R. 1977. Effects of ski area development and use on stream water quality of the Santa Fe Basin, New Mexico. For. Sci. (in press).

Hall, R., G. Hofstra and G. P. Lumis. 1972. Effect of deicing salt on eastern white pine: Foliar injury, growth suppression and seasonal changes in foliar concentrations of sodium and chloride. Can. J. For. Res., 2:244-249.

Herrington, R. B. 1967. Skiing trends and opportunities in the western states. USDA For. Serv. Res. Pap. INT-34.

Menlove, H. O. 1973. NaCl contamination in pine trees determined by neutron activation techniques. Water, Air and Soil Pollution, 2:119-123.

Piatt, J. R. and P. D. Krause. 1974. Road and site characteristics that influence road salt distribution and damage to roadside aspen trees. Water, Air and Soil Pollution, 3:301-304.

Roth, D. and G. Wall, 1976. Environmental effects of highway deicing salts. J. Soil Water Cons., 31:71-73.

Shortle, W. C. and A. E. Rich. 1970. Relative sodium chloride tolerance of common roadside trees in southeastern New Hampshire. Plant Disease Reptr., 54:360-362.

Springfield, H. W. 1972. Using mulches to establish woody chenopods. pp. 382-391 In: Wildland shrubs-their biology and utilization. USDA For. Serv. Gen. Tech. Rep. INT-1.

Table 1. Physiographic characteristics of study sites

Treatment (kg/ha)	Shoulder Width (m)			Distance to Trees (m)			Aspect	Elevation (m)	Slope (°)
	Mean	Max.	Min.	Mean	Max.	Min.			
Light humate (455)	3.76	3.96	3.05	8.87	10.55	7.86	W	3033	25
Heavy humate (910)	7.51	8.69	6.52	9.60	12.04	8.08	W	3014	8
Light straw (1035)	2.20	2.44	1.77	9.29	11.16	7.71	WSW	3130	30
Heavy straw (1925)	0.91	1.22	0.61	9.14	11.58	6.22	N	2957	33
Combination	2.90	4.18	2.26	9.69	12.07	7.83	W	3170	38

Table 2. Influence of straw and humate application on soil moisture content (%). Values indicate the magnitude and direction of the difference of the treatment from the control

Date[1/]	Straw		Humate		Combination 1035 straw 455 humate
	1035 kg/ha	1925 kg/ha	455 kg/ha	910 kg/ha	
1975					
July	-0.8	+1.4	+2.2*[2/]	+4.1*	+1.1
Aug.	+1.3	+2.2	+3.1	+3.5*	+1.0
Sept.	+3.3*	+4.1*	+1.6	+2.6	+2.2
1976					
June	+1.0	+3.9*	+4.4*	+4.7*	+4.4*
July	+2.8	+2.2	+7.1*	+4.2*	+3.3
Aug.	+4.1*	+4.1*	+1.6	+3.9*	+5.2*
Sept.	+4.6*	+5.1*	+3.1	+0.8	+3.9

[1/] Values are means for the entire month.

[2/] Values followed by an asterisk indicate a significant difference between the experimental and control sites at the 0.05 level.

Table 3. Influence of straw and humate application on chloride concentrations (mg Cl/liter) in soil. Values indicate the magnitude and direction of the difference of the treatment from the control

Date[1]	Straw		Humate		Combination 1035 straw 455 humate
	1035 kg/ha	1925 kg/ha	455 kg/ha	910 kg/ha	
1975					
July	-0.008	-0.028	-0.021	-0.093*[2]	+0.003
Aug.	-0.033	-0.033	-0.099*	-0.084*	-0.022
Sept.	-0.041	-0.084*	-0.008	-0.088*	-0.030
1976					
June	-0.015	-0.070	-0.101*	-0.079*	-0.053*
July	-0.003	-0.008	-0.089*	-0.081*	-0.055*
Aug.	-0.087*	-0.063*	-0.077	-0.092*	-0.015
Sept.	-0.065*	-0.027	-0.055	+0.006	-0.025

[1] Values are means for the entire month.

[2] Values followed by an asterisk indicate a significant difference between the experimental and control sites at the 0.05 level.

Table 4. Influence of straw and humate application on organic matter content (%) in soil. Values indicate the magnitude and direction of the difference of the treatment from the control

Date[1]	Straw		Humate		Combination 1035 straw 455 humate
	1035 kg/ha	1925 kg/ha	455 kg/ha	910 kg/ha	
1975					
July	+0.2	-0.2	+1.1	+2.1*[2]	+0.1
Aug.	+0.4	-0.1	+0.8	+1.1	+1.1
Sept.	+0.3	+0.4	+1.3	+0.7	+1.4
1976					
June	+0.6	+6.3*	-0.9	+0.8	+4.1*
July	+0.4	+5.6*	+0.4	-0.1	+3.9*
Aug.	+0.1	+5.2*	+0.1	+0.7	+1.2
Sept.	0.0	+4.3	+0.5	+0.3	+1.4

[1] Values are means for the entire month.

[2] Values followed by an asterisk indicate a significant difference between the experimental and control sites at the 0.05 level.

Table 5. Influence of straw and humate application on understory cover (%). Values indicate the magnitude and direction of the difference of the treatment from the control

Date[1]	Straw		Humate		Combination 1035 straw 455 humate
	1035 kg/ha	1925 kg/ha	455 kg/ha	910 kg/ha	
1975					
July	-0.3	-4.1*[2]	+5.2	-3.6	-2.2
Aug.	+2.2	+0.7	+3.7	+7.5*	+2.2
Sept.	+5.1*	+6.4*	+10.6*	+9.9*	+4.0
1976					
June	+4.0	+5.1*	+2.9	+2.6	0.0
July	+3.0	+8.2*	-0.6	+8.5*	+8.8*
Aug.	+5.4*	+8.0*	+9.9	+12.0*	+4.4
Sept.	+4.5	+10.1*	+4.2	+16.0*	+5.0*

[1] Values are means for the entire month.

[2] Values followed by an asterisk indicate a significant difference between the experimental and control sites at the 0.05 level.

Table 6. Percentages of trees showing visible stress symptoms. T and C represent treatment and control sites, respectively

Date	Straw				Humate				Combination 1035 straw 455 humate	
	1035 kg/ha		1925 kg/ha		455 kg/ha		910 kg/ha			
	T	C	T	C	T	C	T	C	T	C
1975										
July 31	1.0	3.0	1.0	1.0	0.0	0.0	0.0	1.0	1.5	3.0
Aug. 31	2.0	5.0	1.0	7.0	0.0	9.0	0.0	6.0	2.0	7.4
Sept. 30	3.0	19.0	2.5	20.0	3.0	18.0	0.0	21.0	3.0	14.4
Oct. 15	3.0	20.0	2.0	22.0	3.0	20.0	1.0	26.0	5.0	19.0
1976										
June 30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
July 31	0.0	0.0	0.0	2.0	0.0	3.0	0.0	2.0	0.0	4.0
Aug. 31	6.0	9.0	3.0	8.0	1.0	7.0	1.0	5.0	2.0	9.0
Sept. 30	6.0	17.0	4.0	23.0	5.0	12.0	2.0	19.0	4.0	29.0

AD-33 Bookplate (1-63)
U. S. FOREST SERVICE
M. COLLINS
NATIONAL
AGRICULTURAL
LIBRARY
LIBRARY COPY
ROCKY MT. FOREST & RANGE
EXPERIMENT STATION